CO2/ AMMONIA CASCADE SYSTEM CASE STUDY

PROJECT AT A GLANCE

Courchesne Larose Distribution Warehouse

Location: Montreal, Quebec, Canada

Principal Use: Refrigerated Warehouse

Includes: Produce, ripening, loading bays

Gross Square Footage: 124,000

Refrigerated Square Footage: 90,000

Height: 40 feet

Produce Volume: 4,563,442 lbs. food per day
35,000 cases of bananas/week
25,000 cases of grapes/week

Temperature Requirement: 0 to 15 C

Completion: Winter 2012

Times of Operation: 24/7/365

Neelands Refrigeration Limited

CARNOT REFRIGERATION

For the development of their new facility, optimizing energy consumption, reducing the use of HFC's and business risk mitigation, represented the areas of main focus for the owners of Courschesne Larose. Its previous facility was refrigerated using HFC's. Was the new facility to be ammonia? Or was there an alternative design that balances these business, health and safety, and environmental objectives?

From an energy standpoint the challenge presented was to maintain or reduce energy consumption and cost of the existing facility while increasing the refrigerated square footage by almost 400% more than their existing warehouse and increasing product volume by up to 400%.

From an environmental perspective, the challenge is to minimize or eliminate GHG's.

For many food and beverage facilities, their typical number one business risk is ammonia health and safety management for employees, contractors and the adjacent community. Courchesne Larose also desired a refrigeration system that would restrict ammonia to the machine room and limit its volume to avoid E2 measures.

This installation has become a showcase project for demonstrating how all of the above challenges can be met by using a CO2/ NH3 cascade refrigeration system.

The 90,000 square foot refrigerated warehouse includes:

- 22 banana ripening rooms – 35,000 cases weekly
- 3 avocado ripening rooms
- Loading dock with 19 bays
- Banana dock with 3 bays
- Daily volume of 2,069,945 kg

Refrigeration System Configuration

When a site demands large refrigeration capacity the historical solution is ammonia. This natural refrigerant possesses excellent thermodynamic properties and has a broad range of equipment offerings to satisfy a plant of any size.

However, ammonia comes with health and safety risks and increased maintenance as a result of its high toxicity, corrosiveness and flammability. It must also be noted that any ammonia plant containing in excess of 10,000 lbs. must adhere to rigorous EPA, OSHA and other regulatory reporting and emergency planning requirements including;

- Identify substance and place;
- Prepare an environmental emergency plan (E2 plan);
- Implement, update and test the E2 plan annually;
- Provide notice of closure or decommissioning; and
- Report environmental emergencies involving regulated substances.

Also a natural refrigerant, CO2 possesses more advantageous thermodynamic properties when compared to ammonia; has a high volumetric capacity; and unlike ammonia, has low levels of toxicity, corrosiveness and flammability. Currently in most jurisdictions, a leak of CO2 does not require regulatory reporting.

For the engineers at Carnot Refrigeration the challenge was to marry the refrigeration performance benefits that ammonia and CO2 each provided, while minimizing business risk associated with ammonia.

The refrigeration configuration decided upon was an ammonia/ CO2 cascade system. By deploying ammonia on the high side of the system the engineers were able to maximize the scalability benefit of ammonia. By using CO2 on the low side, the engineers were able to harness the thermodynamic characteristics and efficiencies of CO2.

From a risk mitigation perspective, this cascade solution achieved both the goal of minimizing the ammonia charge and restricting ammonia to the mechanical room.

From a performance optimization perspective, the cascade system provided Courchesne Larose with the energy footprint and lifecycle cost they desired.

From the environmental perspective, the cascade system completely eliminated the use of ozone depleting or high global warming HFC's and HCFC's.

Installation Advantages of CO_2

What immediately emerged from this project was that CO2 offered significant advantages when compared to an ammonia only solution.

From a construction standpoint, using CO2 on the low side significantly reduced pipe size. Reducing pipe sizes by as much as 8" to 10" in ammonia versus 2" to 3" with CO2 has a cost ripple benefit on other components such as pipe hangers, insulation, seismic supports, structural requirements, coring and labour. As a result of CO2's volumetric efficiency, installation costs related to pipe size was reduced by 30%.

Heat Recovery Advantages of CO_2

The ammonia/ CO2 refrigeration system is designed to recover direct heat from the discharge gas of the CO2 compressors. By feeding the discharge gas into the recovery coils, the system provides heating for the office, warehouse, shipping dock and workshop. This option provides the recovery capacity (available heat) up to 8x greater than with the use of an intermediate glycol loop.

Free Cooling Advantages of CO_2

By using CO2 with direct expansion in cascade with ammonia, the Carnot system stays in a free cooling mode when the outside temperature is below 8 degrees C. This Carnot Refrigeration patented mode is maintained for 4,000 hours in the Montreal area. During these hours of free cooling mode the ammonia compressors remain completely off. As a result, energy costs and lifecycle costs are reduced and equipment life expectancy is increased.

Customer Reaction

Although the square footage and volume have increased almost 400% since the closing of the previous facility, Christian Denault of Courchesne Larose says their energy costs are similar.

From a business risk and ammonia management perspective, if the new facility had been constructed using ammonia as the sole refrigerant, there would have been a requirement for additional emergency planning regulations and most probably an increase in their liability insurance. The current cascade system contains 4,500 lbs. of CO2 and just 800 lbs. of ammonia – all contained within the mechanical room.

Furthermore, the business risk for loss or damage of product as a result of a refrigerant leak in the product areas is significantly reduced if not eliminated.

Conclusion

The Courchesne Larose distribution facility sets an example of how efficient, safe and environmentally friendly CO2 can be used in what many plant operators feel are traditional ammonia and HFC applications.

This project demonstrates that a diverse range of market sectors, including Food & Beverage process and distribution, can help mitigate global warming, have a positive impact on the environment and drive technological innovation, yet still be commercially feasible. This translates into a highly successful project that will serve the facility for years to come.